Northern Sea Route in shipping: How far is it from being widely adopted?

Abstract

The Northern Sea Route (NSR) is a shipping route running from the Barents Sea, near Russia's border with Norway, to the Bering Strait between Siberia and Alaska. Melting Arctic ice caps are likely to increase traffic in and the commercial viability of the Northern Sea Route. It is expected to become a commercial alternative to the existing shipping network, which is defined by international trading patterns and population centres. However, there is a lack of substantial research on the development and prospect of the utilisation of the NSR. When the NSR can attain mainstream usage remains unexplored. Based on the existing knowledge and scholarship available in the public domain, together with data collected from Northern Sea Route Administration (NSRA) and Equasis database, this paper critically examines the usage of the NSR between 2011 and 2017, and the major factors preventing its wide adoption. It is found in this study that the usage of the NSR has generally been low, and has in fact dropped over the years.

Keywords: Northern Sea Route (NSR); arctic shipping; usage; ships

1. Introduction

Since the opening up of the Northern Sea Route (NSR) for international commercial ships, its potential has been often discussed [1] as an alternative shipping passage from Northern Europe to Asia, and as a potential competitor to the conventional Suez canal route [2] [3], which can sometimes be longer for specific ports and voyage routes connecting Europe to South East Asia [4] [5]. While some parts of the NSR were used in the twentieth century by Soviet and Russian ships, it was only in the 1990s that it was opened for non-Russian flagged commercial ships [6-93]. In 1997, the Finnish oil tanker *Uikku* became the first non-Russian ship to use the NSR [7-94]. Since then, the route has been in use by a variety of ships including tankers and dry cargo ships, and in October 2018, the 3600 TEU capacity ice class Arc 4 container ship *Venta Maersk* joined the list of ice class container ships after successfully completed a test voyage between Vladivostok, Bremerhaven, Saint-Petersburg and Busan using the Northern Sea Route [8-6] [-9-7] [10-8]. This has rekindled speculation and debate on the popularity, potential and viability of the NSR, especially in light of the melting of arctic ice, climate change and other factors [11-9].

However, while modelling and future projections play an important role in analysing the usage of the NSR, and extensive research has been done in attempting to analyse the potential of NSR as a viable option, critical gaps still remain in forming an objective analysis that is based on actual transits that have occurred through the NSR using empirical data, vis a vis modelling and future projections. Strategies that have been used or can be used by ship owners have been discussed in depth in the past, including quantitative analyses [12-81][13-82][14-83][15-84][16-85], however to be fully and continuously realised and assessed, they need to be continuously be compared with current empirical data and historic long term trends. Recent studies of traffic statistics have been carried out using various means of data collection including the use of AIS tracks (Automatic identification system) [17-86] and destination analysis [18-87]. Each of these have their merits and limitations, and suggest that while overall transits have increased over the short term, this increase has not always been appreciable in quantum, and further studies are needed, especially focussing on specific vessel and trade types. In this paper, we add to this existing analysis and discussion by using empirical data from the Center for High North Logistics (CHNL), one of the largest repositories of northern sea route transits using raw data of actual transits that have taken place in the seven year period from 2011-2017 to judge how traffic has actually transpired. We also thereafter attempt to analyse possible reasons for our findings, which we hope will add to the discussion and enable academics to assess future possibilities as well as limitations of the NSR.

1.1. Commercial transits through Northern Sea Route:

While the NSR was already in use, this usage remained sparse, sporadic and focussed on coastal shipping [19-88][20-89][21-90]. This changed in 2010 when larger ships began to undertake voyages through the NSR with increasing frequency. In August 2010, the Russian flagged 114,564 tonnes dwt Aframax tanker *SCF Baltica* (IMO 9305568) became the first Aframax ship to transit the NSR. Soon thereafter, the first non-Russian commercial bulk carrier *Nordic Barents* used NSR to transport iron ore from Sydvaranger Gruve, Kirkenes to Lianyungang China [22-10][23-11][24-12]. Both of these were experimental voyages. In 2011, the NSR was subsequently opened by the NSR authorities for regular ocean going merchant vessels with the maiden voyage of the Singapore flagged tanker *Perseverance* [25-13]. In September 2011, a new record was set by the 160,000 dwt Suezmax tanker *Vladimir Tikhonov* when it used the NSR to carry its cargo of gas condensate from Murmansk to Map Ta Phut, Thailand. The shorter (vis a vis Suez Canal) 2,200 nautical miles voyage took 7.5 days to complete, at an average speed of 12.2 knots, thus leading to further speculation on a possible increased usage of this sea route [26-14]. This was followed by the epic 2012 voyage of the ice class

1A bulk carrier *Sanko Odyssey*, carrying 70,000 tonnes of iron ore from Murmansk, Russia, using one ice breaker as an escort [27-15].

This has catalyzed the discussion about the NSR being an alternative, potentially even replacing the Suez canal for ships sailing between ports in North Europe to China, Japan and South Korea, the salient debate citing it being comparatively shorter than the conventional Suez canal route by up to 45%, which could result in bunker savings of around US $ 600,000 assuming a daily consumption of 50-60 tonnes [-28-16] [29-17]. Other factors cited to promote the use of NSR include the lowering of NSR transit tariffs in 2011, the avoidance of piracy prone areas in the Malacca straits, Yemen and Somalia, the establishment of new ports in the Arctic including the port of Sabetta and new projects including the Yamal LNG project off Kara sea, which are expected to increase vessel traffic [3018]. The Yamal LNG project alone is expected to produce 360 billion cubic meters of LNG from 32 fields in the Yamal peninsula [3119]. The development of existing ports in the Russian Arctic as well as increased ore production in the vicinity of Murmansk could lead shippers to prefer this route. There are 17 Russian ports along the arctic basin with 112 berths, 11.7% of whose cargo is currently under cabotage. Of these, four ports handle 83.8% of the cargo from Russia, namely Murmansk, Arkhangelsk, Kandalaksha and Vitino [3220].

On the other hand, a number of factors act as deterrents for the use of this sea route. The NSR has traditionally been avoided by merchant ships due to a number of reasons. These include the presence of hazardous ice conditions most of the year, the lack of adequate search and rescue facilities for the odd but probably maritime emergency, the high cost of insurance, the virtual necessity for ships to be strengthened to ice class to minimize damage and inadequate maritime infrastructure and ports in the vicinity, all of which increase risks and costs [3321] [3422] [3523]. The NSR is technically ice free for only half the year. Even when said to be technically ‘ice free’, the NSR still can contain pieces of ice floes covering less than one eights of the sea surface, thus qualifying as ‘ice free’, yet still being dangerous to navigation. The necessity of ice breakers or ice strengthening can increase costs, and a vessel beset by ice can lose valuable voyage time.

Meanwhile, from 2011 to 2018, reports have appeared regularly in maritime publications about various “first voyages through the NSR” elucidating the perceived advantages mentioned earlier[3624]. These include the maiden voyage of the Chinese icebreaker *Xue Long* (Snow Dragon) in 2012 [3725] and the October 2018 transit of the heavy lift ship *Tasmanic Winter* which crossed the NSR for the first time, while en route China to Rotterdam, itself loaded with 24 new boats [3826]. Increased funding allocations for projects in the vicinity of the NSR such as the Yamal LNG project have the potential to increase NSR transits. In 2014, it was reported that the Russian government planned to invest 910 million Roubles (US $ 26 million) for establishing ten search and rescue centers along its Arctic coast. In June 2015, under Russia's newly unveiled "Integrated development plan for the northern sea route 2015-30", further feasibility studies were instituted and announcements of development were made [3927]. In October 2018, the CHNL reported federal development projects along the NSR estimated at 587.5 billion Roubles [4028]. These declarations have led to spurts in enthusiasm for the NSR.

1.2. Aims and objectives

Most current published research relates to the *potential* usage of NSR *vis a vis* actual usage. Studies by Wang et al. [2], Stephenson et al. [4129] and Khon et al.[4230] are based on projections, discrete choice and logit models. In 2009, Verni and Grigentin analysed the possibility of the usage of NSR for container shipping [4331]. In 2010, Liu and Kronbak discussed the potential of NSR in terms of its economic viability, in a predictive study before regular transits actually began [4432]. Schoyen and Brathen too compared NSR to the Suez Canal from the perspective of bulk carriers [4533] while Yumashev et al. [4634] estimated that up to 5% of world trade could be shipped using the NSR. However, while projections continue to be made regarding NSR usage, there is need for more updated research on actual transits that have taken place and empirical data that can be used to affirm or verify these projections and predictions. In this, a number of more recent studies have taken into account traffic statistics from various steams including AIS tracking [1281][1382]. However, this needs to be constantly updated and compared with trends and projections in order to gain a wholesome view, in absence of which a large lacunae can exist in our understanding of the NSR. This study aims to address tis by adding to our current repository of knowledge, question earlier held beliefs and attempt to answer some of the questions with respect to reasons for the low transit statistics.

Similarly, while rhetoric about the NSR and its perceived economic benefits are abundant in the maritime news and world media, with proclamations of new heights being reached [4735], "demonstration voyages" and "experimental voyages" using the NSR are regularly engaged in each year [4836][4937][5038] and news articles continuously claim that shipping through the NSR is increasing [5139] [5240]. This leads to the question, what is the evidence to suggest that shipping through NSR is increasing, and if it is, how much? While there has been analysis of traffic statistics over two year periods, there is limited academic research and analysis on the actual quantum of ship transits, vessel types and associated details over a longer period. This presents an impediment to the serious researcher. Current research suggests that the number of transits have increased but not dramatically. However expectations and projections continue to show an upward trend. We ask the fundamental question, is this expectation rational and supported by empirical data? Have transit numbers increased, decreased or have they remained steady over the past few years? Have they matched expectations, superseded them or under-performed? Which vessel types have used the NSR more often and which of them have not used them much? Are there any trends that are noticeable? Currently, there is need for additional analysis of empirical data to answer these important and pertinent questions. Hence there is a need for serious further study regarding transit statistics, trend analysis and identification of the types of ships that have actually used the NSR.

There is need to add to the current research on how the statistics of NSR transits compare to its rival, the Suez Canal to address the question whether the perceived rivalry is justified and if its future potential as an alternative is substantiated by current statistics of its usage.

This paper addresses these requirements for knowledge by analyzing empirical data of actual NSR vessel transits for each year, from 2011 to 2017. We carry out this analysis first by collating existing raw data on NSR transits, and compiling annual transit statistics based on these. Further, we organize this data as per vessel type, and compare it for each year in this seven year period from 2011 to 2017 to identify if there are any trends in NSR usage. We compare the annual transit numbers to the days that NSR was "open for business" to identify it the two are correlated, potentially identifying if a further melting of polar ice might lead to any increase in transits. Finally, we compare the number of NSR transits that have taken place to the transits during the same period through the Suez Canal.

2. Material and Methods

2.1. Data

To find answers to the above stated questions, we collated and analysed raw transit data from the publicly available database ARCTIS (Arctic Resources and Transportation Information System) [5341] [5442] and datasets therein, created and maintained by the Northern Sea Route Center for High North Logistics (CHNL) Information Office. These statistics contain publicly available data on all NSR transits that have occurred over the 7 year period from 2011 to 2017, as published by the NSR CHNL Information Office and NORD university [5543][5644][5745][5846] [5947].

The above data is itself sourced from four entities, namely the Northern Sea Route Administration (NSRA) a Russian federal state budgetary institution which provides the permission and logistics for NSR transits [6048], Atomflot, a Russian federal state unitary enterprise that owns and operates nuclear powered ice breakers that operate in the NSR and provide ice breaking services, towage, salvage as well as arctic cruises [6149], the Arctic and Antarctic Research Institute, an organization located in St. Petersburg and operating under the Russian federal service for hydrometeorology and environmental monitoring [6250] and Ice Pilots, an entity founded by the Murmansk shipmasters association which provides pilotage for NSR transits [6351].

The primary source of vessel types was the vessel designations recorded in the above databases. Where there were ambiguities or where information on vessel types was missing in the original CHNL dataset, this was augmented from the worldwide vessel database of *equasis* which is supported by the European commission, and maritime administrations of France, Singapore, Spain, United Kingdom, Japan, P&I clubs and classification societies [6452], and the TRIS and ITRD databases for tugs and offshore vessels [6553]. For the purpose of this research, we use the definition of an NSR transit as defined by the regulations of Russian federation, Arctic council and NSRA. The Arctic council defines the Northern Sea Route (NSR) as "…the sea route from Northern Europe to South East Asia passing along the Northern coast of the Russian Federation…" [6654][6755]. The NSRA further defines NSR as "shipping within the areas between the Cape Dezhnev and the Kara Gate and Cape Zhelaniya or the strait between the Cape and Franz Josef Land" [6856]. As per Art. 5.1 of Russian Federal Law dated 30 April 1999 amended by N-132 FZ dated 28 July 2012, this consist of the region bound by the 68 35 East longitude on the western edge along the north eastern part of Kara sea and extends up to 168 58'37" West on the eastern edge along Chukchi sea [6957] [7058].

2.2. Organization and Analysis

We collated and organized this raw data into (a) Aggregate transit data per year [table 1] and (b) transit data per year per vessel type [table 4].

Year	**Total Transits**	**First transit (dd.mm.yyyy)**	**Last transit (dd.mm.yyyy)**	**NSR open**	
2011	41	29.06.2011			
2012	46	23.06.2012	18.11.2012	148	days
2013	71	28.06.2013	28.11.2013	153	days
2014	53	28.06.2014	17.11.2014	142	days

2015	18	30.07.2015	10.12.2015	133	days
2016	18	16.07.2016	17.11.2016	124	days
2017	27	31.08.2017	6.12.2017	97	days

Table 1. Aggregate NSR transit data per year for the period 2011-2017

To compare vessel types, we further grouped the data on vessel transits into five categories, namely Category 1-5 [table 2]. We created these categories based on the vessel types and cargoes that they carried, to test the hypothesis of whether there might exist a correlation between vessel cargoes / trades and usage of NSR.

Category 1	Tankers (Chemical, Product, Oil) and LNG
Category 2	Dry cargo ships: Bulk carrier, General cargo, Reefer and Container
Category 3	Passenger and Cruise ships, Seismic, Research and Hydrographic ships
Category 4	Ice breakers, Tugs, Offshore support and supply vessels (OSV), Diving ship, Salvage and Rescue vessel
Category 5	Coast guard and fishing vessels

Table 2. Categories of vessels using NSR.

These specific categories were chosen for three reasons. Firstly, due to the common practice in the maritime field of grouping ships by the type of cargo carried and the purpose of ships [7159] [7260]. Secondly, the manner in which original raw data is published by the CHNL allowed these vessel types to be clearly identified. Thirdly, trade patterns in these broad categories will enable observers and researchers to identify specific trends related to specific industries related to their study and correlate it to specific projects that are currently in progress in the Northern Arctic and that might arise in the future.

2.3. Limitations

During our research, we have been cognizant of the fact that there are limitations to the data presented in ARCTIS by the CHNL. While the organization is the central repository of all transits through the NSR, it is also a commercial organization involved in the promotion of the NSR, thus there may exist an inherent conflict of interest. Classifications of vessel types has varied in CHNL statistics in 2011, 2012 and 2013 after which the vessel classifications have remained the same. Hence we cross checked vessel types and tonnages for the vessel name and IMO number (where available) using the database of the IMO (International Maritime Organisation), Equasis and Det Norske Veritas, thus addressing any errors in spelling. We have also double checked press releases from companies, to ensure that only those transits that actually transpired are included in the data. CHNL only records transits that pass through all the transit points along the NSR, hence many vessel movements that do not pass all the transit points (for example, movements of offshore vessels that undertake voyages from a port near NSR to an oil rig in the Russian EEZ and return thereafter to the same port) are often not included in their statistics, neither are short sea coastal voyages and voyages undertaken without pilots. In reading our research findings, these factors must be given due cognizance. Furthermore, three distinct limitations of data that we felt need elucidation have been discussed in depth below, which must be kept in mind when analyzing the given data and research.

3. Results

3.1. Usage of NSR and Transit Statistics

We find that transit numbers have not been as flattering as the press coverage would initially have suggested. A total of 274 ship transits took place through the NSR during the seven year period from 2011-17, an average of 39 transits per year [table 1 and 2]. 2013 saw the highest number of transits to date (71) after which they have reduced to a low of 18 in 2015 and 2016, increasing slightly to 27 in 2017.

Year	Total Transits	First transit (dd.mm.yyyy)	Name of ship	Departure port	Destination	Last transit (dd.mm.yyyy)	Name of ship	Departure port	Destination	NSR open	
2011	41	29.06.2011	*Perseverance*	Vitino (Russian federation)	Ningbo		*Mar Adriana*	Rotterdam	Vladivostok		
2012	46	23.06.2012	*Varzuga*	Pevek - Anadyr	Murmansk	18.11.2012	*Hammerfest*	Tobata		148	days
2013	71	28.06.2013	*Varzuga*	Murmansk	Nakhodka	28.11.2013	*Indiga*	Murmansk	Petropavlovsk - Kamchatskiy	153	days
2014	53	28.06.2014	*Kapitan Khlebnikov*	Dezhnev	Zhelania	17.11.2014	*Ivan Ryabov*	Pevek	Zhelania	142	days
2015	18	30.07.2015	*Yasniy (with floating crane SPK 42150)*	Saint Petersburg	Petropavlovsk - Kamchatskiy	10.12.2015	*Tor Viking*	Seattle	Landskrona	133	days
2016	18	16.07.2016	*Kapitan Khlebnikov*	Anadyr	Murmansk	17.11.2016	*Pomor*	Bergen	Kholmsk	124	days
2017	27	31.08.2017	*Tian Jian*	Lianyungang	Esbjerg	6.12.2017	*Chukotka+*	Murmansk	Korf	97	days

Table 3. Overview of ship transits 2011-2017.

3.2. Profile of vessels using the NSR

We assimilated data of vessel types using Categories 1,2,3,4 and 5 based on the type of ship and the nature of its trade and cargo, in order to give a more representative image of the nature of vessels that, data would indicate, favour usage of the NSR. Data shows that NSR has been most "popular" with Categories 1 and 2 ships (categories as described in the previous section), namely tankers and dry cargo, which combined accounted for 81% of the ships. 44% of them were "Category 1 ships" (Tankers: chemical, product and oil and LNG) and 37% of them were bulk carriers and dry cargo ships including general cargo, reefer and occasionally, container ships ("Category 2 ships").

Year	Category 1: Tanker (chemical, product, oil) and LNG	Category 2: Bulk carrier / General cargo / Reefer / Container	Category 3: Passenger / Cruise / Seismic / Research / Hydrographic vessel	Category 4: Ice breaker / tug / Offshore support and supply vessel / Diving ship / Salvage and rescue vessel	Category 5: Coast guard / Fishing	**Total for the year**
2011	17	14	3	6	1	**41**
2012	28	10	0	8	0	**46**
2013	40	24	3	3	1	**71**
2014	27	17	6	3	0	**53**
2015	2	9	1	5	1	**18**
2016	1	9	2	6	0	**18**
2017	5	19	0	1	2	**27**

Table 4. Categories of vessels using NSR.

"Category 3 ships", consisting of ice breakers, tugs, offshore vessels, supply ships, diving, salvage and rescue vessels accounted for 12% of the total traffic. The number of cruise ships that have used the NSR has been low, accounting for just 5% of the total traffic along with seismic, research and hydrographic vessels. Coast guard and fishing vessels accounted for just 2% of the total traffic.

However, the preponderance of tankers has not been a steady trend. While they were the dominant vessel type in 2011-14, it was dry cargo ships that were the highest users of NSR from 2015-17, accounting for half the transits in 2015 and 2016, and for 70% of the transits in 2017.

4. Discussion

4.1. Number of transits

As shown in Figure 1, from 2011-17, a total of 271 transits took place through the NSR. The highest number of transits per year took place in 2013 (71 transits) after which the numbers have generally declined.

In 2011, the first year when commercial transits commenced, 41 transits took place through the NSR from 29 June 2011 onwards. Thereafter transit numbers increased to 46 transits (2012) and to a peak of 71 transits (2013) which has not been surpassed since. Thereafter the number of transits dropped sharply to 53 (2014) and even further to 18 (2015 and 2016). In 2017, there was a slight rise to 27 transits.

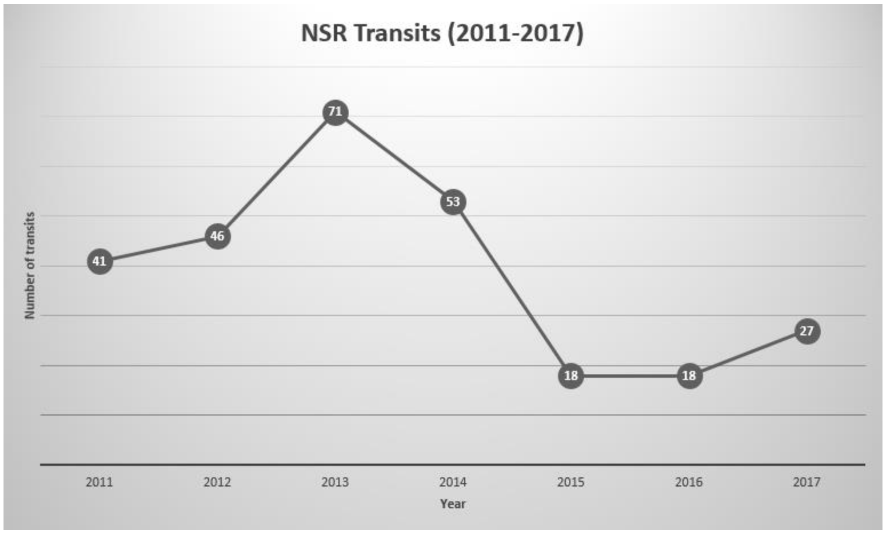


Figure 1. NSR transits 2011-2012

Thus, based on empirical data, it may thus be surmised that the usage of NSR has generally been low, with a high point of 53 transits in 2014 and a subsequent low of 18 transits each for two years 2015 and 2016. Contrary to the expectation of increasing NSR transits, data shows us that after 2013, transits have generally reduced for 3 years and only increased slightly in 2017 to 27. This is still lower than the number of transits in the first year of NSR opening up.

Possible reasons:

The reasons for this reduction are worth exploring. Prima facie, these reasons could include navigational issues (ice), commercial issues, environmental conditions (fog), geographical locations of loading and discharge ports, as well as trade related reasons. Unlike container ships which base their routes on a hub and spoke logistics model, routes adopted by bulk carriers and tankers are purely based on the loading and discharge port. Thus, ships loading in Australia and discharging in China always use one of the channels between islands of Indonesia, East Timor and Papua New Guinea without touching Singapore straits unless they need to pick up bunkers or stores. As of 2019, there are very limited operational ports abundant in loading bulk, oil and gas ports along Northern Europe that may be able to compete with other currently prevailing ports. This may not change even if fresh mineral deposits are discovered. For example, any new coal deposits will have to compete with the prevailing popular coal loading ports of Indonesia and Australia, both located just a week of clear waters from China, Japan and South Korea. Even if new manganese deposits are discovered along Northern Europe, the NSR would have to display merits as compared to the clear deep water oceanic route from Groote Eylandt (the largest Manganese loading port of Australia) to S.E. Asia. A similar case exists for Iron ore, wherein any route between Northern Europe to S.E. Asia would have to demonstrate itself as safe and economical as the current deep water routes from the minerals rich Pilbara region of Australia which houses the largest iron ore exporting ports in the world to S.E. Asia, the latter being the pivot point of the argument for NSR.

A further detailed examination of the reasons was not within the purview of this research, as this is in itself an extensive topic worth a separate detailed study and worth researching.

4.2. Vessel types

We find that tankers (chemical, product, oil) and LNG were the largest users of NSR for the initial four years from 2011-14, accounting for 41% to 61of the total transits. Thereafter their share fell compared to dry cargo ships. Dry cargo ships on the other hand have seen their share of transits decrease from 34% in 2011 to 22% in 2012. Thereafter they have steadily increased in share to 19 transits in 2017 translating to 70% of the total transits for that year. Category 4 ships (ice breakers, tugs, off shore supply, search and rescue ships) are the third largest users of the NSR, with total 32 transits during the period. Cruise ships and research vessels are a niche category that accounted for a total of 15 transits or 12.5% of total transits.

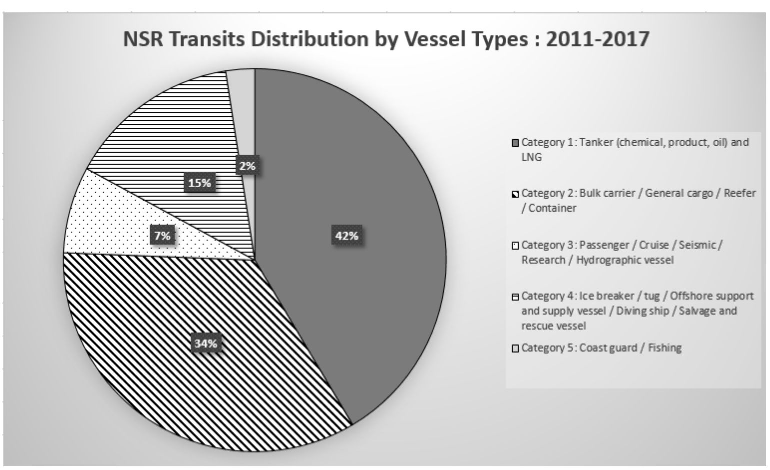


Figure 2. Usage of NSR by vessel type.

Coast guard and fishing vessels rarely use the NSR for transits, with a grand total of just 5 transits. The share of tankers using NSR fell to 6% in 2016, with just one tanker transit of the Russian flagged product tanker *Yaroslav Mudriy* in November 2016, carrying 8,470 metric tonnes of oil products. As of 2019, under the belt and road initiative of China, pipelines for transporting any new oil and gas finds in Russia appear to be a favored solution [7395]. This is due to the obvious advantages of such pipeline connectivity, which can be continuous, less dependent on the quantum of oil to be transported, and safe from the vagaries of an oceanic voyage through ice filled and story waters [7496]. Hence, even in light of any new oil and gas explorations and findings, little chance of correlation can be expected with regards to the use of NSR.

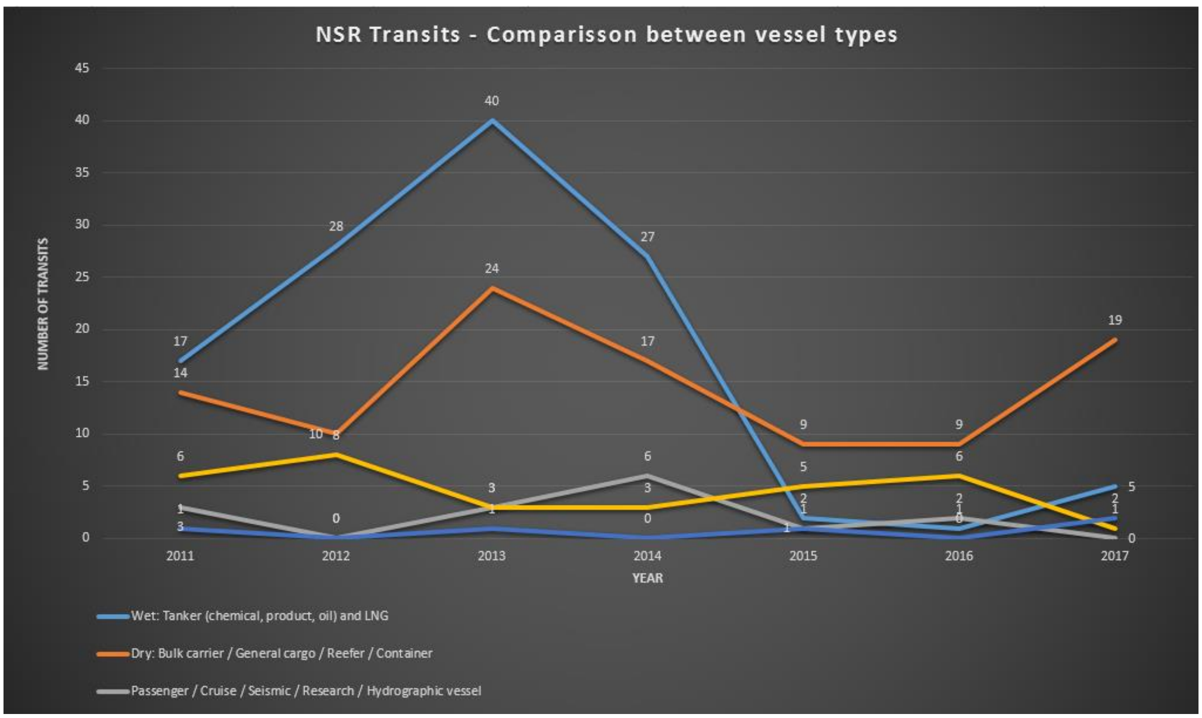


Figure 3. NSR transits 2011-2017. Comparison between different vessel types.

4.2.1.Tankers

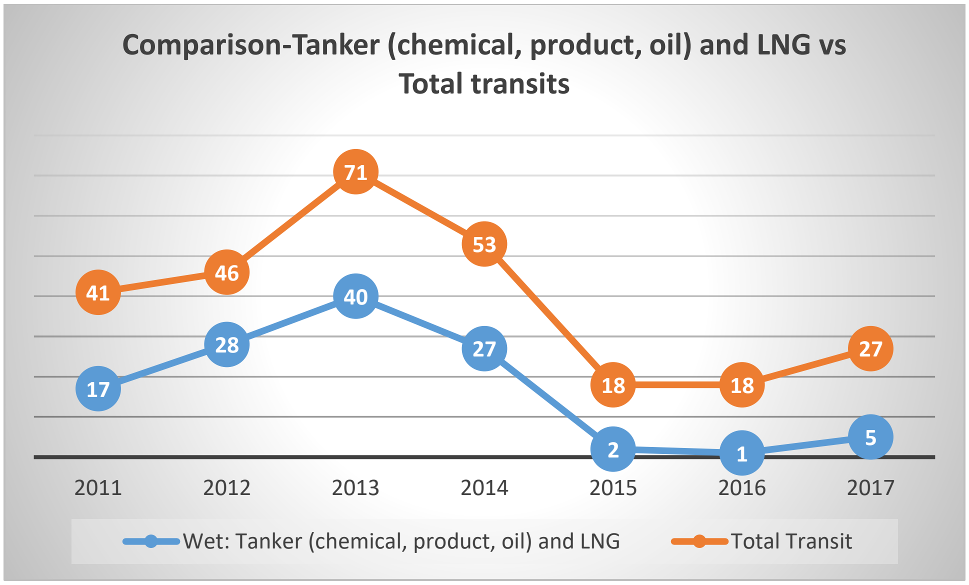


Figure 4. Category 1 - Tanker transits and comparison with total transits.

The number of tankers that used NSR rose steadily from 17 (2011) to 28 (2012) and 40 in 2013. Thereafter, numbers fell to 27 (2014). In 2015, only 2 tankers *Svyatoy Petr* and *Palladiy* used the NSR, and in 2016, only one tanker *Yaroslav Mudriy* navigated through it. This number rose in 2017 to 5 tankers, namely *Egvekinot*, the LNG carriers *Chr. De Margerie* and *Boris Vilkitskiy* and two transits by the product tanker *Chukotka+*. Data suggests that while the Yamal LNG project produced 82.8 billion cubic meters of LNG in 2017 [7561], it has not resulted in any significant increase in the number of tankers using NSR. This could be due to the fact that the oil fields at Yamal are also connected by gas pipelines that run over land in Russia through Surgut, Vorkhuta, Salekhard, and Nizhnevartovsk [7662]. Even though Yamal has not yet reached its full capacity, increased LNG production in Yamal need not result an increase in LNG ship traffic in NSR. Further, ships continue to be susceptible to the vagaries of nature in this region, thus defeating its use. In November 2017, the tanker *Chukotka+* attempted to cross the NSR without ice breaker assistance, however it got stuck in the ice in Sannikov strait, necessitating it to remain beset for a few days until the ice breaker Yamal was able to rescue it on 22 November [7763]. Milakovic et al. also conclude that ice conditions will be one of the three decisive factors for NSR [7864].

4.2.2.Bulk carriers, General Cargo and Reefers

The number of transits by category 2 ships (dry cargo including bulk carriers, general cargo, reefer and container ships) has generally followed a sine curve in its numbers, with a currently upward trend. In 2011, 14 bulk carriers transited the NSR, in 2012 this reduced to 10. In 2013, it increased to 24 dry cargo transits after which it steadily reduced over the next two years to 17 (2014) and 9 each in 2015 and 2016. This however accounted for half the NSR transits. In 2017, 19 transits took place by dry cargo ships. Of these, very few are container ships, and a majority are general cargo ships, reefer and bulk carriers. 2017 saw the highest number of dry cargo ships transiting the NSR including 4 heavy lift ships (*Tian Jian, Da An, Tian Fu and Tian Le*), 8 general cargo ships, 3 transits by reefer ships and two transits by the pallet ship "*Winter Bay*". However, this larger proportion of heavy lift ships, and general cargo ships were mostly involved in specific construction projects in the Arctic catered to by the companies COSCO and BBC [59]. Hence there is no reason to suggest that this trend will necessarily continue in 2018 and thereafter, unless largescale port and island construction projects take place in the Arctic.

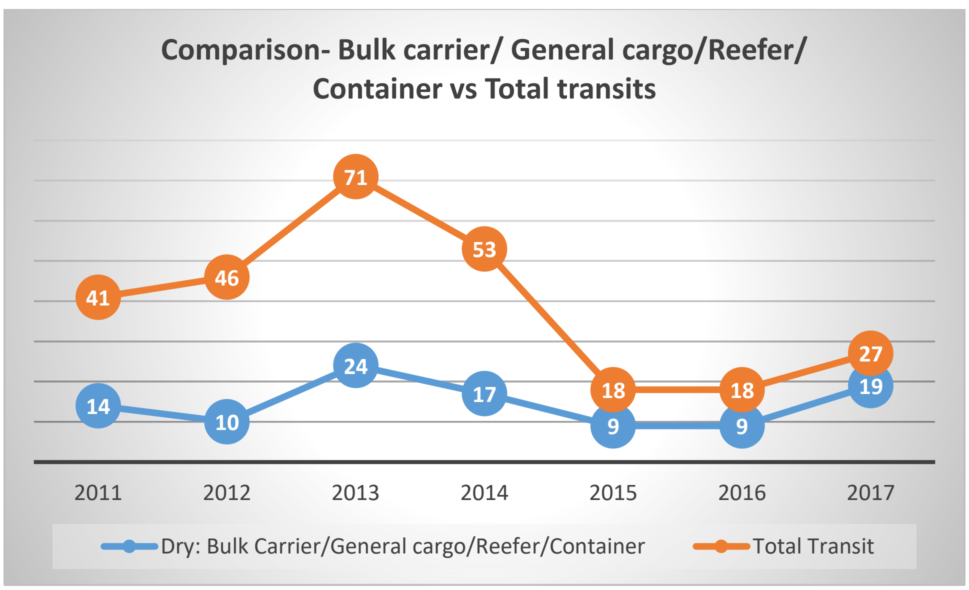


Figure 5. Category 2 - Dry cargo ship transits and comparison with total transits.

However, these heavy lifts were specifically engaged in port developments, hence it would be wrong to expect a repetition of these voyages unless more ports are developed.

4.2.3. Passenger, Cruise, Seismic, Research, Hydrographic vessels (Category 3):

The first seismic ship to transit NSR was *Polarcus Alima* which departed Hammerfest on 15 September 2011 and arrived at Cape Dezhnev 9 days later completing its a passage of 3000 nautical miles [11]. However, this category of ships, viz. passenger cruise ships, seismic, research and hydrographic vessels has seen unsteady transit numbers, with just 3 transits in 2011, none in 2012, 3 in 2013, a maximum of 6 in 2014, a drop to 1 transit in 2015, 2 in 2016 and none in 2017. These include the 2014 transit by *Akademik Tryoshnikov*, the 2014 and 2016 transits by passenger ship Hanseatic, the 2014 transit by passenger ship *Kapitan Khlebnikov* and the 2015 transit by the Hapag Lloyd expedition ship *Bremen*. While adventure cruises to the arctic are often advertised among select groups of tourists including tours to Baranov station [7965], data shows that they are infrequent and have not increased the number of NSR transits significantly. It is of note that these expeditions often visit the Arctic, but can remain outside the sea area limits of NSR. For example, *Bremen* has so far transited the NSR only twice, in 2015 and in November 2018 [7965].

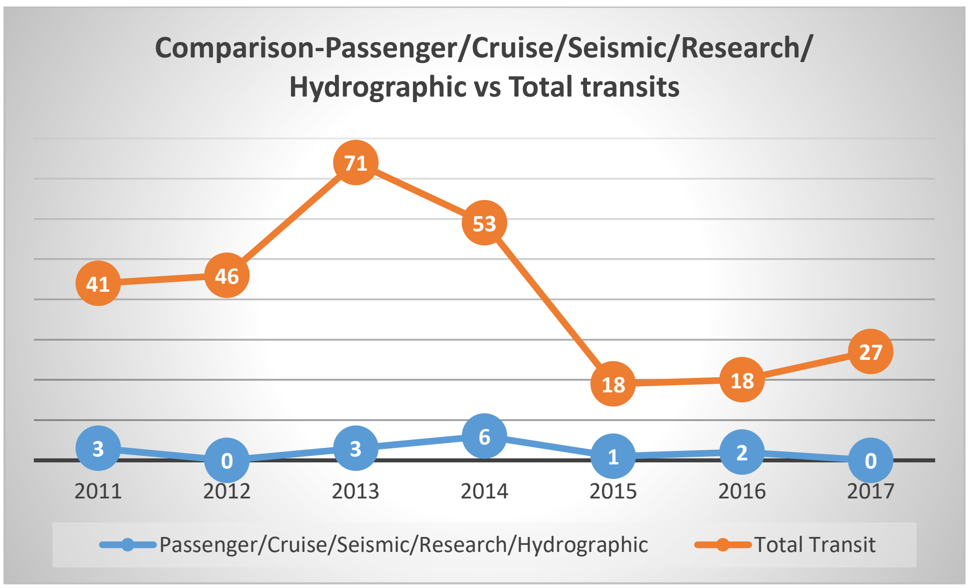


Figure 6. Category 3 ship transits and comparison with total transits.

Thus, data suggests that arctic cruises using the NSR remain a niche category, especially since reaching the North Pole (a popular aim of many arctic cruises) does not necessitate a full transit of the NSR. As of 2019, there were no ships sailing from China, Japan or Korea offering arctic cruises.

4.2.4. Icebreaker, tug, offshore support vessel, diving ships, salvage and rescue vessels

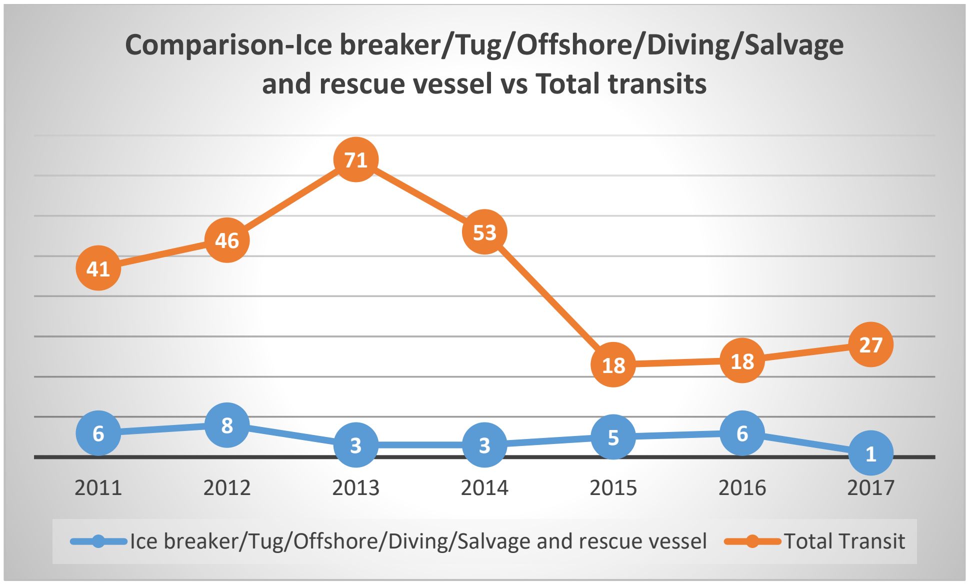


Figure 7. Category 4 ship transits and comparison with total transits.

Category 4 ships (ice breakers, tugs, off shore support and supply vessels, diving ships and search and rescue vessels) accounted in most years for the third largest number of transits, varying from 4% to 33% of the total transits. Their numbers have varied between 8 transits (2012) to 1 transit in 2017 by the supply ship *Fedor Ushakov*. However, ice breakers that operate continuously in the NSR without exiting it are not included in the transit statistics published by the CHNL, as the latter focusses on transits by commercial ships. This also accounts for the fact that data resulting from AIS tracks can vary from that published by CHNL. The same ice breaker can also be engaged in servicing a number of ships during the same period, depending on their needs.

4.2.5. Coastguard and Fishing vessels

As per NSR transit data, the route is least used by Coast guard and fishing vessels, with numbers usually varying between 1 and 0 transit per year, though in 2017, it was used by two fishing vessels, *Volk Arktiki and Odissey-1*.

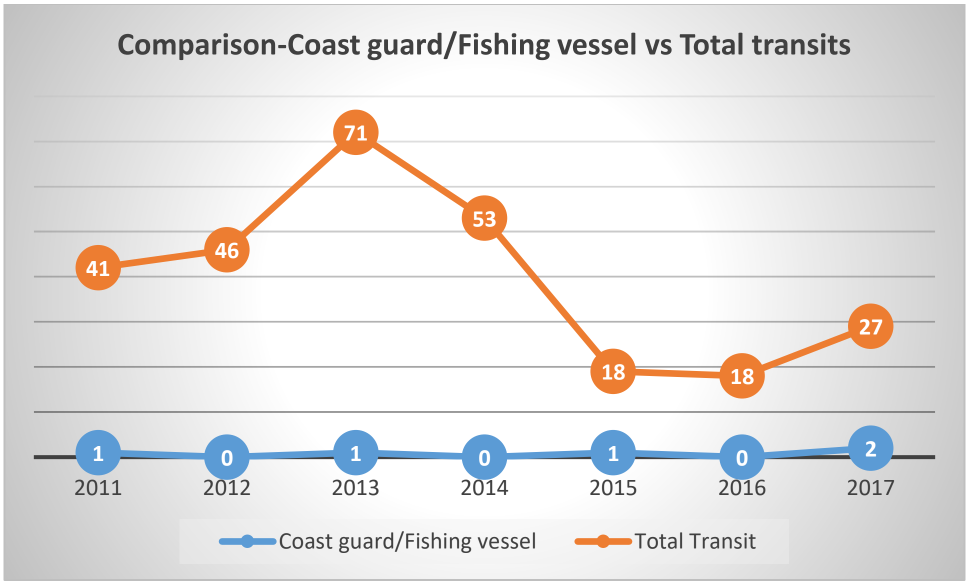


Figure 8. Category 5 ship transits and comparison with total transits.

4.3. Mitigating factors - Navigation season, and Days open for transits and navigation

Using climatic models and the A1B scenario of the Intergovernmental panel on climate change, Khon et al. [8066] conclude that the number of days that the NSR would be usable could most probably increase. However, the days when NSR has actually transacted business, as measured by the difference between the first transit and last transit dates, has steadily reduced after its peak (153 days) in 2013. NSR itself has been open for transits for varying durations throughout the observation time period of 2011-17. Though studies have indicated increased melting of polar ice caps, the number of days that the NSR was used for transits (measured as the difference between the first and last transits) has varied between 148 days in 2012 and 153 days in 2013, to a steadily reducing 142 days (2014), 133 days (2015), 124 days (2016) and just 97 days (2017). Current transit statistics do not indicate any increase in the number of days NSR was open with any increased melting of arctic ice. Having said that, this measure of “days open for business” also depends on the ships lined up for transits.

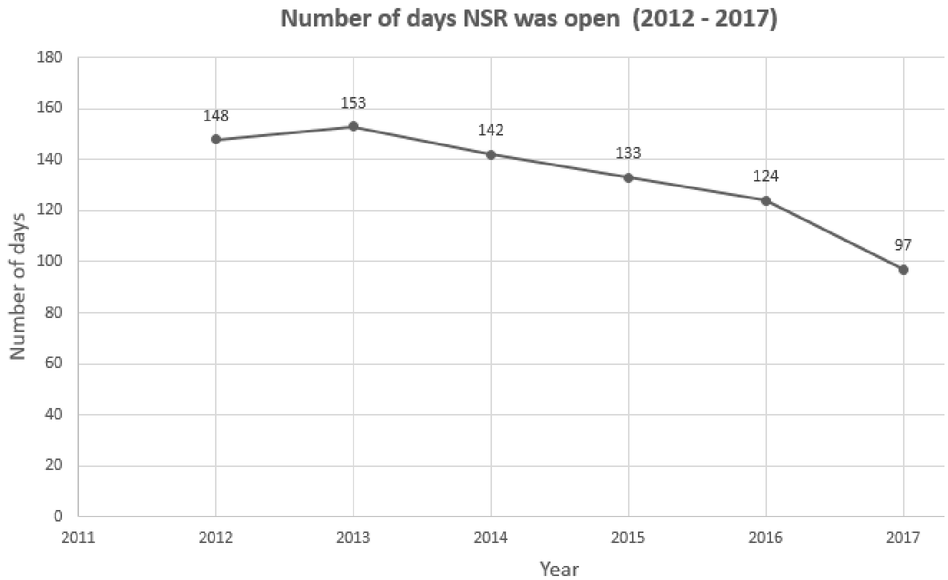
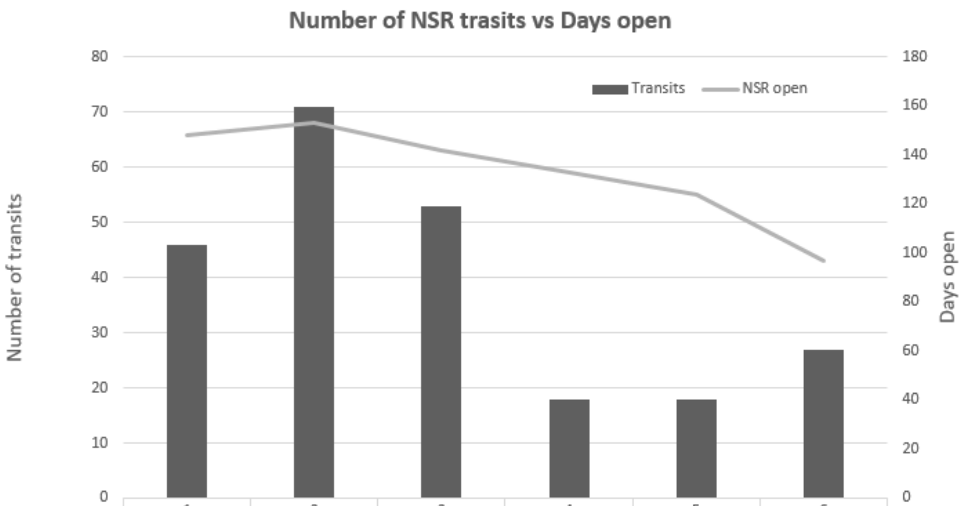


Figure 9. Number of days NSR was open (2012-2017)

It is noteworthy to mention here that the NSR is not open for navigation throughout the year [8167]. During the Arctic winter, NSR is covered with thick ice preventing any navigation. The navigation season commences in June each year, as ice thins down and can be broken by conventional ice breakers and ice class ships [table 2 NSR open days and first last transit]. While some navigation does take place from February to March in Barents Sea, none takes place in Kara Sea and Laptev Sea in the vicinity of Taimyr Peninsula due to thick ice [8268]. The last transits of the season are usually towards the end of November / beginning of December. To analyse the given data, we measured the number of days NSR was open, as the difference between the first transit and last transit.

NSR was open for navigation for a maximum duration in 2013 (5.1 months or 153 days). In all other years, this period has been lesser, consistently reducing since 2013, to 142 days (2014), 133 days (2015), 124 days (2016) and the lowest so far of 97 days in 2017. While there have been reports in 2015 that NSR could potentially be open for navigation all year long, current transit data does not support this supposition [8369].



	1	2	3	4	5	6
Transits	46	71	53	18	18	27
NSR open	148	153	142	133	124	97

Figure 10. NSR 2012-2017: Days open vs number of transits.

4.3.1.Ice free waters

The Polar Code (regulation 2.5) and the WMO sea ice nomenclature define "ice free waters" as "…waters where there is no ice present. If ice of any kind is present, this term shall not be used." [8470] [8571]. However, while reports are often encountered referring to the NSR being generally ice free during certain times of the year and thus speculating independent transits by ships that are not ice strengthened [8672] [8773], this can be misleading as the term "ice free" is a misnomer and does not mean free of ice. It may contain very open or brash ice (polynya), [8874] as well as drift ice [8975], making navigation by non-ice class ships virtually impossible, and making the assistance of ice breakers often necessary even for ice class ships. Simulations and studies by Bekkers et al. [9076] suggest that the polar ice caps might be melting faster than earlier envisaged, however, our study suggests that this has not resulted in any increase in NSR transits. On the contrary, any presence of ice, even if it is in small quantities has three major impacts on transits, namely an increase in transit costs due to ice breaker escorts, higher premiums for insurance coverage and lower permissible speeds, thus defeating any saving in distance.

4.4. Comparison with Suez canal

The number of transits through NSR are very few compared to Suez Canal [table …]. They were just 0.10 - 0.43% of Suez Canal transits from 2011-17. In 2013, NSR saw 71 transits while Suez

Canal saw 16,595 transits [9177] [9278]. The Suez Canal is open for navigation all year long, while NSR has been open only for 153 to 97 days each year.

Year	NSR Transits	Suez canal Transits	NSR Transits / month	Suez canal Transits / month
2011	41	17800		
2012	46	17224	9	1435
2013	71	16595	14	1383
2014	53	17148	11	1429
2015	18	17483	4	1457
2016	18	16833	5	1403
2017	27	17550	8	1463

Table. Comparison between number of transits of NSR and Suez Canal (2011-2017).

Even after considering this variation, we find that the per month transits for NSR are 1/159th those of Suez Canal in 2011 (0.6289%) and 1/183th the number in 2017. Based on the data, it is improbable that the NSR will prove to be a competition for the Suez Canal any time soon.

4.5. Limitations of data

We identified three additional limitations in the raw data published by CHNL. To ensure that this does not adversely impact our research, we took the following precautions.

4.5.1.Data included in Annual statistics

CHNL listed every vessel's name and flag for each transit. However, the level of detail of other information provided for each ship has not been consistent each year. For transits of 2011, data on vessel types only mentioned categories – tanker, bulker, refrigerator (sic.), container, general cargo, ice breaker, diving ship, cruiser, towing boat, seismic research vessel, hydrographical vessel and tug/supply ship. In 2012 and 2013, the vessel type was not mentioned at all, only the cargo carried during the transit was mentioned. This could occasionally be confusing as "FD" (Fuel diesel) has been listed as cargo, making two surmises possible, a tanker with FD as cargo as well as a general cargo ship carrying diesel fuel as bunkers. Occasionally, bulk carriers have been mistakenly written as MT, for example: Nordic Orion in ballast has been given the prefix MT when in actuality it is a bulk carrier. *Yuri Topchev* is referred to as a multi-function vessel while it is registered as a tug in other maritime databases [9379]. Occasionally ships have been categorized as "Coast guard" in one year and "Border Guard" in another (for example: *PS-824* is categorized as a "Border guard vessel" in 2011 and *PS-825* is categorized as "Coast Guard service" in 2013). Similarly, the CHNL statistics do not always specify the vessel type for each ship. For example the CHNL data for the August 2013 transit of *Tekhnolog Konyukhov* does not list its vessel type. In 2016, CHNL classified oil tankers also as general cargo ships (example: the oil products tanker *Yaroslav Mvdryy* IMO IMO 9046576 10,463 dwt is recorded in the 2016 CHNL NSRLIO statistics as a general cargo carrier with oil products as its cargo.

In all such cases, we cross checked the vessel type from three alternative sources, namely the Equasis vessel data registry [www.equasis.org], marine traffic [www.marinetraffic.com website] and vessel finder [www.vesselfinder.com] and tabulated the vessel type relevant to the voyage. Where available, open data bases of DNV and classification societies were also used to iron out any such doubts.

4.5.2. Inconsistencies in data related to ice breakers and cruise ships

Secondly, the same vessel has sometimes been registered in the statistics alternately as Icebreaker, Passenger ship and cruise vessel. This is because some ice breakers are multipurpose in their capabilities. They can also function as cruise ships for specialty novelty arctic cruises, as well as for hydrographic purposes. For example: Russia's nuclear ice breakers *Arktika* and *Taimyr* are also employed for arctic cruises. So are *Hanseatic, Kapitan Khlebnikov, Akademik Tryoshnikov* [9480].

In such cases, we have recorded the vessel exactly as listed by the CHNL. Similarly in 2016, *Kapitan Khlebnikov*'s type is recorded by the NSRLIO as "icebreaker" but its cargo is recorded as passenger. In such cases, we have recorded the vessel type based on the purpose of the transit.

4.5.3. Missing / unspecified data

The level of detail of data published each year by the CHNL has been different. There has not been any standardization over the years. For example: the statistics published for

2011 were basic, and did not have any dates of entry into and exit from NSR. Hence it was not possible to account for the number of days that the NSR was open in 2011. We addressed this by only reporting on data that has either been consistently published each year, or which could be verified by other means. For 2015, 2016 and 2017, additional vessel types like “Heavy lift” were added. In 2014, CHNL included tugs, supply vessels and ice breakers all under one category “tug/supply/icebreaker”. We have addressed this by choosing the broad categories listed in 2.2 to erase any errors due to ambiguity.

5. Conclusions

The success of NSR as a worthwhile navigation option and even as an alternative to Suez Canal, for shipments between Northern Europe and the East Asia can be measured by analyzing the number of transits that have taken place through the NSR. In our research, we analyzed the data from transits through NSR from 2011 to 2017. However, the data and our study of the transits during this seven year period shows that transit numbers have consistently remained very low. While they did increase from 2011 to 2013, these numbers were always less than 71 per year, dipping to a low of just 18 transits in the years 2015 and 2016. This shows that the route has not been as popular with shippers and ship owners as was projected. The reasons for this have already been enumerated above, and include the high risk, the limited days that NSR is truly open for business, high costs and high risks.

Furthermore, data shows that any comparison between NSR and Suez Canal is unfounded. NSR barely registers 0.4 % of the number of transits that Suez canal is used for, as the latter registered 16,595 transits in 2013 while the NSR registered a mere 71. Ships that have used the NSR are mostly tankers and dry cargo ships, with specific ports whose locations necessitate the use of NSR or single demonstration voyages for test purposes.

Any increase in the use of NSR, even in recent years, has been limited to very few ship numbers. This is due to a multitude of reasons, including the presence of ice, navigational dangers, fog which restricts visibility, inadequately surveyed waters and charts, inadequate presence of search and rescue facilities, extreme harsh weather, added costs of insurance, additional pilotage and ice breaker assistance. Even for voyages between the Northern extremities of China and Northern Europe, there is no data to suggest that NSR is being used. The few ships that do get publicized in the maritime media and press releases like *Xue Long* in 2012 and *Tasmanic Winter* in 2018 are primarily one off experimental and exhibition / demonstration voyages. The quantities of cargo that would necessitate the use of NSR or justify the additional costs are currently not present in the Russian Arctic. Container ships have hence rarely used the NSR since 2011 due to the lack of any hub ports along the Northern coast of Russia. Current empirical data does not suggest any reason for any major change in this trend.

Though environmental studies have suggested that the polar caps have been melting, leading to an increase in “ice free waters” in the arctic, the number of days that the NSR has been “open for business” as actually reduced, from 148 days in 2012 and 153 days in 2013, to 142 days (2014), 133 days (2015), 124 days (2016) and just 97 days (2017). This suggests that the number of ice free days has actually reduced consistently. Further, even if the presence of ice reduces, there is no data to suggest that the NSR will become a popular route option for shippers any time soon.
The only exception might be LNG shipments between Russian Arctic and China, but at the moment, there are few such shipments or loading ports. Further, the use of pipelines to transport this gas is a far more popular, safer and viable option. Thus, it will take a considerable time before the NSR can be discussed as a viable option for shipments between Northern Europe and the far Eastern nations of Asia, including China, Japan and Korea.

In addition to the above, the reasons for the reluctance to use NSR could be multifold and are worth further exploring. The exact impact that could occur if LNG trade between Russian Arctic increases is also worth exploring, but necessitates further data. Until then, NSR remains a niche route, and is expected to remain so. Its transit numbers are also too small for it to be a significant competition for the Suez Canal for the time being.

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